Research Report

Air Force Major Defense Acquisition Program Cost Growth Is Driven by Three Space Programs and the F-35A

Fiscal Year 2013 President's Budget Selected Acquisition Reports

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Preface

This report provides the results of Air Force weapon system cost growth analyses based on the RAND Corporation's internal Selected Acquisition Report database. The database provides consistent, current metrics to support analyses both within RAND Project AIR FORCE (PAF) and in the Air Force acquisition community. This work assesses, quantifies, and documents cost and schedule growth of Major Defense Acquisition Programs (MDAPs) and provides data and detailed program histories. A forthcoming companion document, *Causes of Cost Growth: Themes from Six Programs with Extreme Cost Growth*, assesses root causes of cost growth in six Air Force MDAPs of recent years using both quantitative and qualitative analyses.[1]

The research reported here was commissioned by the Deputy Assistant Secretary for Acquisition Integration, Office of the Assistant Secretary of the Air Force for Acquisition, Headquarters U.S. Air Force, and conducted within the Resource Management Program of PAF as part of a project called "Umbrella Acquisition Policy and Cost Analysis." The project monitor was the technical director of the Air Force Cost Analysis Agency.

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[1] Lorell, Leonard, and Doll, draft in process.

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Summary

Acquisition cost growth in military weapon systems has long drawn the attention of U.S. Department of Defense (DoD) leaders, Congress, and the military services. Reliable estimates of weapon system acquisition costs and a comprehensive understanding of total life cycle costs (acquisition plus operations and support) can help inform decisionmakers as they manage current acquisition programs and plan for future programs. For methodology and approach, this research leverages three prior RAND analyses: *Historical Cost Growth of Completed Weapon System Programs*,[1] *Is Weapon System Cost Growth Increasing? A Quantitative Assessment of Completed and Ongoing Programs*,[2] and *Weapon System Cost Growth in the New Century: Is It Growing?*[3] This work is narrower in scope than the prior analyses, focusing on contrasting continuing Air Force acquisition programs with those that are now complete.

With additional years of data now available, and the corresponding ability to include meaningful data from programs begun in more-recent years, the Deputy Assistant Secretary for Acquisition Integration, Office of the Assistant Secretary of the Air Force for Acquisition, asked RAND to revisit this topic. This analysis includes programs with major milestones through early 2011.

During the past four decades, the military services and the Office of the Secretary of Defense (OSD) have managed hundreds of very large weapon system acquisition programs. These programs, designated Major Defense Acquisition Programs (MDAPs), account for more than 40 percent of weapon system acquisition funding appropriated by Congress.[4] RAND maintains an internal database of costs and schedules for these programs, as reported in Selected Acquisition Reports (SARs) dating back to the 1960s.

In this work, we analyze cost growth in Air Force–managed MDAPs. Differing definitions of cost growth provide differing insights into program outcomes. In this analysis, we define cost growth as that for the entire acquisition effort, as measured from the point of commitment to system development. This commitment typically occurs at the time of the program's Milestone B (MS B) and the associated major development contract award.

The analysis focuses on those MDAPs that contain the highest levels of development activity and that, at a minimum, have proceeded through the acquisition process to a point at which a

[1] Arena, Leonard, et al., 2006.

[2] Younossi et al., 2007.

[3] Leonard, Wallace, and Graser, 2011.

[4] Based on the DoD fiscal year (FY) 2014 budget request, in which MDAPs make up $69.4 billion of $167.6 billion in DoD acquisition funding (Office of the Under Secretary of Defense [Comptroller]/Chief Financial Officer, 2013).

portion of the production units envisioned at the program's MS B were produced and delivered to the warfighter. These MDAPs are broken into two groups:

- Continuing programs are those currently in the process of being acquired and that have substantial future funding. These programs are at least five years past MS B but are less than 80 percent funded. They are neither near the beginning nor near the end of their acquisition phase.
- Complete programs are those no longer being acquired or that are so far along in the acquisition process (at least 80 percent funded) that their costs are unlikely to change further.

This analysis facilitates better understanding of cost growth in the Continuing programs, in which further cost growth might be controlled. There are seven Continuing programs: C-5 strategic airlift aircraft Reliability Enhancement and Re-engining Program (RERP), F-35A (Air Force variant of the Joint Strike Fighter tactical aircraft), Advanced Medium-Range Air-to-Air Missile (AMRAAM), Joint Air-to-Surface Standoff Missile (JASSM), Advanced Extremely High Frequency (AEHF) satellite communication system, Evolved Expendable Launch Vehicle (EELV), and Space-Based Infrared System, High Component (SBIRS High) space surveillance satellite program.

Our analysis used multiple metrics to compare simple and dollar-weighted average cost growth in the Continuing and Complete programs and to identify those programs driving these averages.

Findings

The averages for all acquisition cost growth metrics except development are substantially higher in Continuing programs than in Complete programs, indicating that Continuing programs have already experienced a higher rate of cost growth than Completed programs have. After normalizing for production quantity changes over time, the cost growth differences between these two program sets are statistically significant. Three characteristics of the Continuing programs help explain their higher cost growth: The programs are longer, a larger fraction of them are space programs, and none of them is an electronics program. Statistical testing of these three characteristics shows that each is positively correlated with higher cost growth in most if not all measures thereof.

The lower development cost growth in Continuing programs was a change from the prior year's analysis, in which Continuing programs had higher cost growth in all metrics.[5] This change occurred due to the FY 2013 President's Budget, in which three Air Force MDAPs were removed from future acquisition funding plans: the National Polar-Orbiting Environmental Satellite System (NPOESS) and C-130 tactical airlift aircraft Avionics Modernization Program

[5] Leonard, Wallace, and Graser, 2011.

(AMP) were cancelled, thus removing them from the analysis, and the Global Hawk remotely piloted surveillance aircraft program was truncated, thus reclassifying it as a Complete program. Development cost growth in these three programs was in excess of 150 percent.

Three Continuing space programs with extreme cost growth—SBIRS High, AEHF, and EELV—drive the higher cost growth averages. However, in dollar terms, cost growth in the Air Force portion of the F-35 program (F-35A) dominates the data set. On a percentage basis, F-35A cost growth is above average,[6] but not nearly high enough to be classified as extreme (i.e., cost growth larger than one standard deviation above the mean). However, at $87.1 billion (FY 2012 dollars) it is much larger in dollar terms than the cost growth of all other Continuing programs combined.

The three space programs with extreme cost growth, plus the F-35A, make up more than 95 percent of the cost growth in the Continuing programs. With the 2013 President's Budget's cancellation of future acquisition in the NPOESS, C-130 AMP, and Global Hawk programs, those programs, which also experienced extreme cost growth, are no longer part of future MDAP budgets.

There appears to be minimal cost growth thus far in MDAPs begun between 2003 and 2011 that have substantial Air Force funding. Six MDAPs with both high development content and substantial Air Force funding were begun in these years. Three—the Multi-Platform Radar Technology Insertion Program (MP-RTIP), B-2 strategic bomber aircraft Radar Modernization Program (RMP), and B-2 Extremely High Frequency Increment 1 (EHF I-1) satellite communication upgrade—were relatively low value by MDAP standards. These three are categorized as electronics programs and short in duration, both characteristics that are statistically significantly associated with lower cost growth. They are categorized as Complete programs and had essentially zero cost growth. The other three—Global Positioning System IIIA (GPS IIIA) satellite navigation system, Small Diameter Bomb II (SDB II), and KC-46A aerial refueling and strategic transport aircraft—are considered to be New programs because not enough time had passed between their MS Bs and this analysis to make an assessment of their cost growth in relation to that of other programs that are further along in the acquisition process. Through the FY 2013 President's Budget SARs, none of these three programs has had cost growth of more than a couple of percentage points.

Four programs in aggregate are expected to consume a large fraction of annual Air Force MDAP acquisition funding in the coming 20 years: F-35A, EELV, KC-46A, and the Long-Range Strike Bomber. The first two are well along in the acquisition process but have decades of production to come. Opportunity remains to stem the cost growth in these programs. The second two are earlier in the acquisition process and thus provide greater opportunities to ensure affordability and minimal future cost growth. Controlling the cost of these four high-value

[6] This average is that defined by all Continuing plus Complete Air Force programs.

programs is essential to ensuring both their affordability and that of the entire Air Force weapon system acquisition portfolio for decades to come.

Acknowledgments

RAND's internal SAR database and this work would not have been possible without the sustained support of the Office of the Deputy Assistant Secretary of the Air Force for Acquisition Integration, including Bobby W. Smart, Richard W. Lombardi, and Blaise J. Durante. Likewise, we are grateful for the assistance and support of Ranae P. Woods, technical director for cost and economic analysis research for the Air Force Cost Analysis Agency, and Jay H. Jordan before her in that capacity.

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Abbreviations

AABNCP	Advanced Airborne Command Post
ACAT	acquisition category
AEHF	Advanced Extremely High Frequency
AFCAA	Air Force Cost Analysis Agency
ALCM	Air Launched Cruise Missile
AMP	Avionics Modernization Program
AMRAAM	Advanced Medium-Range Air-to-Air Missile
APUC	average procurement unit cost
AWACS	Airborne Warning and Control System
CDR	critical design review
CMUP	Conventional Munitions Upgrade Program
DoD	U.S. Department of Defense
DSCS III	Defense Satellite Communications System, phase III
EELV	Evolved Expendable Launch Vehicle
EHF I-1	Extremely High Frequency Increment 1
EMD	engineering and manufacturing development
FAB-T	Family of Advanced Beyond Line-of-Sight Terminals
FRP	full-rate production
FSD	full-scale development
FY	fiscal year
FYDP	Future Years Defense Program
GBS	Global Broadcast System
GLCM	Ground Launched Cruise Missile
GPS	Global Positioning System
GPS IIIA	Global Positioning System IIIA
GRP	Guidance Replacement Program
ICBM	intercontinental ballistic missile
JASSM	Joint Air-to-Surface Standoff Missile
JDAM	Joint Direct Attack Munition
JPATS	Joint Primary Aircraft Training System
JSTARS	Joint Surveillance Target Attack Radar System
JTIDS	Joint Tactical Information Distribution System
LRP	low-rate production
LRS	Long Range Strike
MAIS	Major Automated Information System

MDAP	Major Defense Acquisition Program
MILCON	military construction
MM	Minuteman
MP-RTIP	Multi-Platform Radar Technology Insertion Program
MS	milestone
MS B	Milestone B
NPOESS	National Polar-Orbiting Environmental Satellite System
O&M	operations and maintenance
OSD	Office of the Secretary of Defense
PAF	RAND Project AIR FORCE
PAUC	program acquisition unit cost
PB	president's budget
PDR	preliminary design review
RERP	Reliability Enhancement and Re-engining Program
RMP	Radar Modernization Program
RPV	remotely piloted vehicle
RSIP	Radar System Improvement Program
SAR	Selected Acquisition Report
SBIRS High	Space-Based Infrared System, High Component
SDB II	Small Diameter Bomb II
SDD	system design and development
UAV	unmanned aerial vehicle
UE	user equipment
WGS	Wideband Global Satellite Communications

Chapter One. Selected Acquisition Report Data and Analytics

In the past four decades, the military services and the Office of the Secretary of Defense (OSD) have managed hundreds of very large weapon system acquisition programs. These programs, known as Major Defense Acquisition Programs (MDAPs), account for more than 40 percent of all weapon system acquisition funding appropriated by Congress. Cost growth and schedule slips in MDAPs cause difficulty in managing acquisition budget accounts and delays in delivering required capabilities to the warfighter. This analysis is one in a series designed to improve MDAP outcomes and develop better cost-estimating tools for use by the acquisition community.

We analyze cost growth in Air Force–managed MDAPs and in MDAPs managed by the U.S. Department of Defense (DoD), the Navy, or the Army that have substantial Air Force funding. Differing definitions of cost growth provide differing insights into program outcomes. In this analysis, we define cost growth as that for the entire acquisition effort, as measured from the point of commitment to system development. This commitment typically occurs at the time of program's Milestone (MS) B (MS B) and the associated major development contract award. The analysis focuses on those MDAPs that contain the highest levels of development activity and that, at a minimum, have proceeded through the acquisition process to a point at which a portion of the production units envisioned at the program's MS B were produced.

Selected Acquisition Report Data

To help the Air Force understand cost growth in MDAPs, RAND Project AIR FORCE (PAF) maintains an internal database of costs and schedules for these programs as reported in Selected Acquisition Reports (SARs) dating back to the 1960s. The database tracks costs and major milestones for each program's acquisition in more than 300 MDAPs that, in aggregate, have published more than 5,000 individual SARs. This database includes MDAPs related to all the services and DoD, all weapon system types, and all acquisition-related costs. The database is unclassified, thus allowing the broadest possible use of the data to support analyses both within PAF and in the Air Force–wide acquisition community.

The purpose of the SAR database is to provide the current cost and schedule status of MDAPs in all stages of the acquisition process and to track the growth of costs and slips in schedule over time for each program. The database specifies consistent baseline definitions for major milestones in order to facilitate comparisons between programs, services, weapon system types, and the evolving acquisition process over the decades. The database allows for analyses over time that

- track cost and schedule estimate changes
- analyze trends in the accuracy of cost and schedule estimates
- identify correlations between cost and schedule changes
- provide understanding of budgetary impact.

To isolate different types of cost growth, the database tracks program estimates in both then-year (budget) and base-year (constant) dollars.[1] This allows us to isolate cost growth caused by inflation in each program. Cost estimates are also tracked as budgeted and with adjustments for quantity changes. The latter allows us to track unit cost growth in both procurement and for the program in total.

In the remainder of this chapter, we provide sample cost growth charts to illustrate the types of analyses that are possible with the database, and we illustrate the ways in which MDAPs can be categorized across the acquisition timeline.

Sample Cost Growth Charts

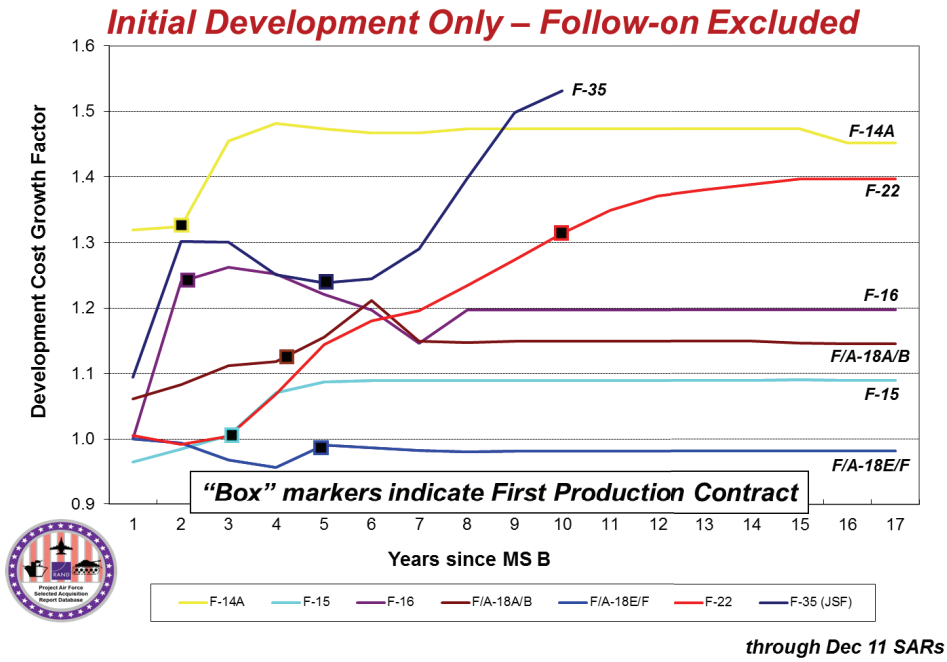
Figure 1.1 provides an example of the type of analyses made possible by the database. The figure displays cost growth for the initial development program in total at each year past the MS B for seven fighter aircraft programs.[2] The MS B typically coincides with the commitment to a weapon system development program, so it is the official or tacit beginning for all MDAPs that require substantial development prior to production.

In the figure, the calendar or fiscal year (FY) in which each program's MS B occurred is irrelevant. Arranging the cost growth data this way allows us to compare development cost growth across several programs at equivalent times after the decision to move forward with major development. *Major development* is defined as the award of the primary full-scale development (FSD), engineering and manufacturing development (EMD), or system design and development (SDD) contract.

[1] SARs report program costs in both then-year and base-year dollars. Service and appropriation specific inflation indexes are utilized to convert base-year cost data in programs to a common base year for all programs, thus facilitating their comparison.

[2] F-35 program cost growth shown represents the U.S. program in its entirety. This includes F-35A, B, and C aircraft variants.

Figure 1.1. Development Cost Growth over Time in Fighter Aircraft Programs

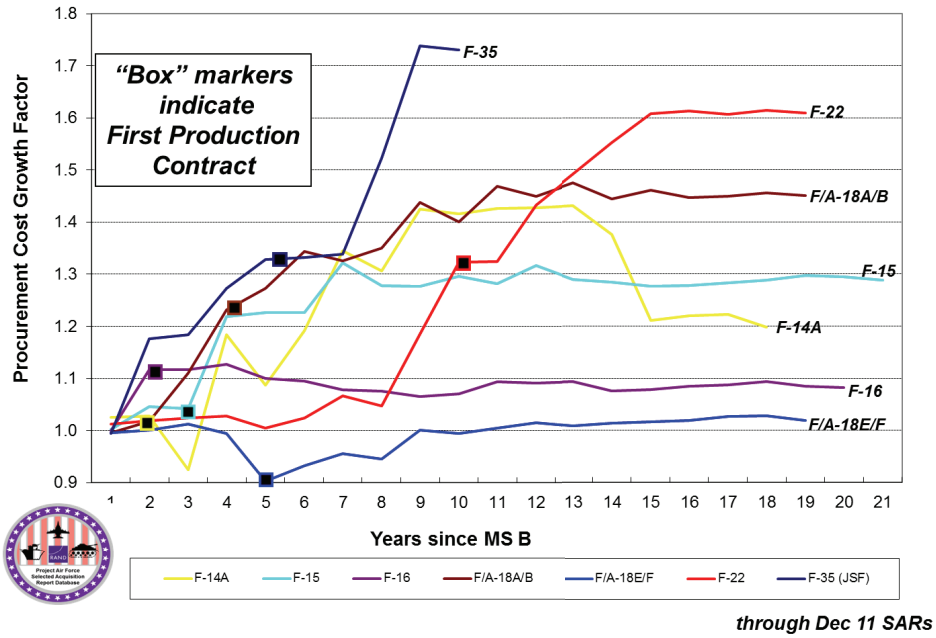


The x-axis shows the number of years from the program's MS B. The y-axis shows development cost growth as a factor, with 1.0 equaling no growth, 1.1 equaling 10 percent growth, 1.2 equaling 20 percent growth, and so on. The box on each program's development cost growth line represents the point after the MS B at which the program's first significant production contract was awarded, typically that for the program's initial production lot. The cost growth calculations exclude development funding in the years after the program's initial development effort that is typically added late in the development effort for capabilities not envisioned at the time of the MS B. Removing this funding for follow-on development activities, such as block upgrades and modernization efforts, ensures that the cost growth calculations over time represent (as closely as is possible) the capabilities included in the estimate at the time of the MS B.

Figure 1.2 shows similar data for procurement cost estimates in the same seven fighter aircraft programs. In these data, the effects of quantity changes have been removed, allowing us to understand how unit cost estimates grew over time. After the MS B, the portion of the entire production run that is currently estimated and was estimated at the MS B are compared to calculate cost growth. If the current program has more units than the MS B baseline estimate, then the cost growth for the baseline quantity is used for this calculation. For example, in the F-16 tactical fighter aircraft program, 650 U.S. production aircraft were envisioned at the MS B; eight years later, the program planned to build 2,165 U.S. production aircraft. The cost growth shown is for the initial 650 aircraft. If the current program has fewer units than the MS B baseline estimate, then the cost growth calculated is based on the current quantity. The F-35

program envisioned 2,852 U.S. production aircraft at the MS B;[3] eight years past that milestone, the program planned to build 2,443 U.S. production aircraft. The cost growth estimate shown is for the 2,443 aircraft.

Figure 1.2. Procurement Cost Growth over Time in Fighter Aircraft Programs, Adjusted for Quantity Changes



Figures 1.1 and 1.2 illustrate just how high cost growth is in the F-35 program compared with that of other fighter aircraft programs. Not only does the F-35 program have the highest cost growth of all fighters represented, but this level of cost growth occurs at a relatively early point in the typical 20-plus-year acquisition duration of a fighter program, and the total value of the F-35 program far exceeds that of any previous fighter aircraft program, regardless of whether quantity changes are factored in. Future additional cost growth in the F-35 program remains likely, given that its initial operational test and evaluation is not yet complete. In contrast, data for all other fighter programs extend to the point at which cost growth has stabilized.

Figures 1.1 and 1.2 provide just a small sample of the type of analyses that are possible given the breadth and depth of the database. Similar figures are available for these same seven programs showing procurement cost growth when not adjusting for quantity changes, and program total cost growth (including development, procurement, military construction [MILCON], and acquisition-related operations and maintenance [O&M]), both adjusted and

[3] F-35 models A, B, and C.

unadjusted for quantity changes. Also available are a similar series of figures for nonfighter aircraft and a separate series of figures covering space systems.

Figures of this type can be created for programs measuring cost growth from MS A, B or C, and for all weapon system types DoD-wide,[4] including

- aircraft (includes fixed-wing unmanned aerial vehicles [UAVs] and remotely piloted vehicles [RPVs])
- helicopters (includes rotary-wing UAVs and RPVs)
- missiles (tactical, cruise, strategic, and torpedoes)
- vehicles (includes tanks)
- ships and submarines
- electronics (radios, telecommunication terminals, avionics upgrades, weapon guidance kits)
- space (satellites and launch vehicles).

Major Defense Acquisition Program Estimation and Categorization in the Acquisition Timeline

In the past, any MDAP with substantial development effort (and therefore funding) submitted its first life cycle cost estimate at the time of its MS B.[5] This estimate included all costs from the initiation of development efforts through the decades-long operational period for the system. Separate estimates were generally developed by both the program office and an independent body, such as the Air Force Cost Analysis Agency (AFCAA). The two estimates were then reconciled to create a service cost position, which was presented to the defense acquisition executive at the time of the MS B review. If the program passed the review, then the cost estimate became the baseline for the MDAP. Thereafter, the estimate was updated annually and reported to Congress via the program's SAR. Note that the analysis herein addresses only the acquisition portion of the overall life cycle estimate, so the program's operations and support costs are not part of this analysis.

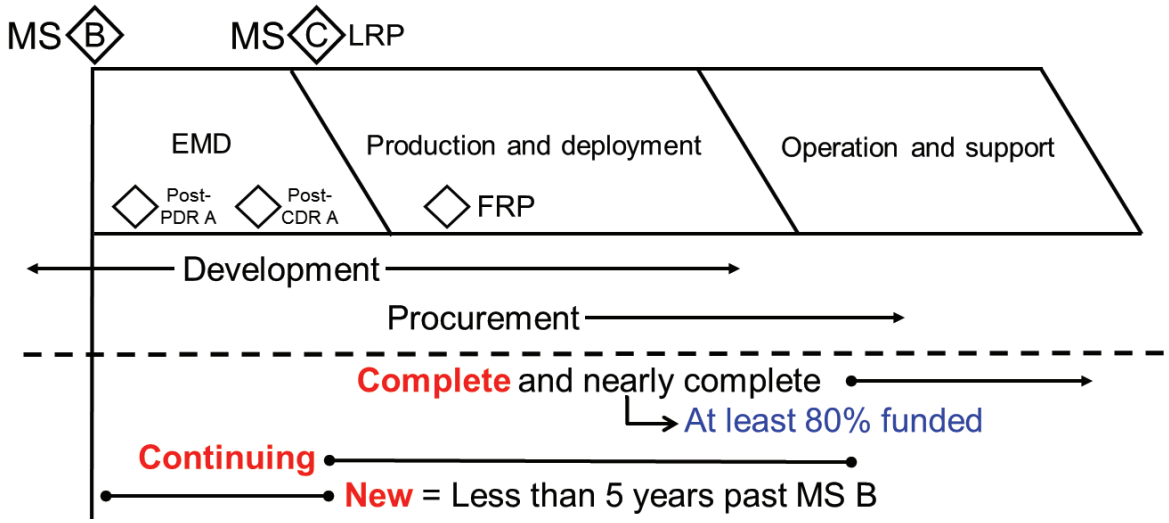
To analyze acquisition cost growth, we first categorize programs based on their position in the timeline of the acquisition process. Major development, and thus the commitment to an acquisition program, typically begins at MS B, which is the primary milestone from which we measure cost growth. In older MDAPs that employed similar versions of this same basic process, the initiation of major development activities through the award of a contract at or near the time of the program's Milestone II was used as the point from which we measure acquisition cost growth. The acquisition timeline from MS B is shown in the top of Figure 1.3.

[4] Major Automated Information System (MAIS) programs do not report to Congress via SARs unless the program is also categorized as an MDAP.

[5] With the Weapon Systems Acquisition Reform Act of 2009 (Pub. L. 111-23), the policy changed to require a complete life cycle cost estimate at MS A.

In general, the cost growth and associated analyses in this work include Complete and Continuing programs. The former are generally used as a reference point for the latter to assess outcomes for programs currently under active Air Force acquisition management. The New programs are not appropriate for such comparisons. We explain each category below.

Figure 1.3. MDAP Categorization in the Acquisition Process Timeline



NOTE: LRP = low-rate production. PDR = preliminary design review. CDR = critical design review. FRP = full-rate production.

New Programs

We define New programs as those that are less than five years past MS B. New programs are typically not far enough beyond their MS Bs for substantial cost growth to have occurred. Although some cost growth may have occurred, in most programs, it is far too early to estimate the level of additional future cost growth each program may experience. Difficulties in executing MDAPs to the plan established at MS B take time to work through the process of determining mitigation plans and assessing the cost and schedule impacts of the proposed resolutions. Because of this delay, the costs of problems uncovered in MDAPs can take years to manifest themselves. For these reasons, MDAPs that are less than five years past MS B are not good analytical candidates to compare with Complete programs and thus are generally excluded from such comparisons. Of all post–MS B programs, policy changes have the greatest opportunity to change the outcomes of these programs. For the Air Force, the New programs are

- KC-46 aerial refueling and strategic transport aircraft
- Small Diameter Bomb II (SDB II)
- Global Positioning System (GPS) IIIA (GPS IIIA).

Continuing Programs

Continuing programs are at least five years past MS B but are not yet 80 percent funded. These programs are in the heart of the acquisition process. They are far enough along in that process to potentially develop significant cost growth but are not so advanced in the process that future cost growth is unlikely. Measuring cost growth in Continuing programs gives insight on how well current programs are performing. These programs are far enough into acquisition to evaluate performance, yet have enough acquisition execution remaining that policy changes may affect their final outcomes. For the Air Force, the Continuing programs are

- Air Force variant of the Joint Strike Fighter (F-35A)
- C-5 strategic airlift aircraft Reliability Enhancement and Re-engining Program (RERP)
- Advanced Medium-Range Air-to-Air Missile (AMRAAM)
- Joint Air-to-Surface Standoff Missile (JASSM)
- Advanced Extremely High Frequency (AEHF) satellite system
- Evolved Expendable Launch Vehicle (EELV)
- Space-Based Infrared System, High Component (SBIRS High).

Complete Programs

Complete and nearly Complete programs have ceased SAR reporting or will do so shortly. They are at least 80 percent funded through the current fiscal year. These programs should experience little if any additional cost growth. Given their late stage in the acquisition process, Complete programs provide an excellent reference from which to assess the Continuing programs. These programs are too far into their acquisition for changes in policy to significantly affect their outcomes. For the Air Force, the Complete programs are

- F-15 air superiority fighter aircraft
- F-16 tactical fighter aircraft
- F-22 air superiority fighter aircraft
- A-10 ground attack aircraft
- B-1B strategic bomber aircraft
- C-17 strategic airlift aircraft
- E-3A Airborne Warning and Control System (AWACS) aircraft
- E-4 Advanced Airborne Command Post (AABNCP) aircraft
- RQ-4A Global Hawk remotely piloted surveillance aircraft
- T-6A/B Joint Primary Aircraft Training System (JPATS) aircraft
- E-8 Joint Surveillance Target Attack Radar System (JSTARS) aircraft
- Air-Launched Cruise Missile (ALCM)
- Ground-Launched Cruise Missile (GLCM)
- AGM-65A/B television-guided air-to-ground Maverick missile
- AGM-65D imaging infrared air-to-ground Maverick missile
- E-3 Sentry AWACS Radar System Improvement Program (RSIP)
- B-1B Conventional Munitions Upgrade Program (CMUP), computer segment

- B-1B CMUP, Joint Direct Attack Munition (JDAM) segment
- B-2 strategic bomber Extremely High Frequency Increment 1 (EHF I-1) satellite communication upgrade
- B-2 Radar Modernization Program (RMP)
- EF-111A Tactical Jamming System aircraft modification
- Global Broadcast System (GBS) terrestrial satellite transmit/receive system
- JDAM bomb guidance kit
- Joint Tactical Information Distribution System (JTIDS) class II terminals
- Minuteman (MM) intercontinental ballistic missile (ICBM) Guidance Replacement Program (GRP)
- Multi-Platform Radar Technology Insertion Program (MP-RTIP)
- GPS first-generation (Block I/II/IIA) satellite system
- GPS second-generation (Block IIR/IIR(M)/IIF) satellite system
- Defense Satellite Communications System, phase III (DSCS III) communication satellite system
- Titan IV heavy space-launch vehicle
- Wideband Global Satellite Communications (WGS) system.

Major Defense Acquisition Programs Suitable for Cost Growth Analysis

The SAR database contains 111 MDAPs managed by the Air Force that generated at least one SAR each in the past 40-plus years. Of these programs, just 36 both have cost estimates at their MS Bs and have progressed far enough into the acquisition process to be analytically useful. They represent the vast majority of cost growth contained within the database—in both dollar and percentage terms—and were therefore used in the analyses that follow.

The remaining 75 programs cannot be used to assess cost growth from MS B for one or more of the following reasons:

- The vast majority began SAR reporting at their MS Cs or at some point after their MS Bs. Therefore, they do not have MS B cost estimates from which to measure cost growth.
- Some of the 75 programs are New, and not enough time has elapsed from their MS Bs to make them suitable for comparative analyses.
- The rest are not in the analysis sample because of termination or because their values fell below the SAR reporting threshold well before program completion. These programs did not progress far enough into the acquisition process to be analytically useful.

Excluding these 75 programs from the analyses is necessary for meaningful analysis; however, excluding these programs does not mean that a significant fraction of the dollars associated with cost growth are excluded. This is the case because each excluded program can be characterized by at least one of the following:

- began at MS C because little or no development funding was required and therefore the program contained lower acquisition risk. Lower risk generally equates to lower cost growth in percentage terms.

- began as an acquisition category (ACAT) II or III and grew in costs to become ACAT I sometime after MS B. These programs are of low dollar value by ACAT I standards; thus, their cost growth is low in dollar terms.
- are less than five years past their MS Bs and therefore have not yet experienced substantial cost growth
- were terminated and thus delivered few if any operational units, rendering measurement of their cost growth meaningless.

Values for Cost Growth Metrics

Table 1.1 shows simple average[6] values for cost growth, one standard deviation above the average, and the sum of these two—to which we refer as the *extreme cost growth threshold*[7]—for the five cost growth metrics measured from MS B. The percentages in Table 1.1 were developed using the combined Air Force data set of Continuing and Complete MDAPs.

The average length of time from MS B to final SAR in the Complete programs is 13.0 years. The average length for Continuing programs to each program's most recent SAR (dated December 31, 2011, in this analysis) is somewhat longer (14.6 years). Cost growth tends to be higher in longer programs, but the cost growth difference attributable to the average program length difference in the two data sets is small. Keeping this in mind, direct comparison of the two data sets is appropriate.

There are two types of cost growth metrics: budgetary and unit. Budgetary metrics are unadjusted for program quantity changes from the quantity planned at MS B. These measures show just how much more, in real terms (after removing effects of inflation), was spent or is planned to be spent in programs than was estimated at each program's MS B.[8] The table shows Budgetary metrics, including mean, one standard deviation, and the extreme cost growth threshold values for Budgetary metrics, for development, procurement, and program total. Also shown are Unit metrics, which are those adjusted for program quantity changes from the quantity planned at MS B.[9] These metrics, calculated for procurement (average procurement unit cost

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[6] Simple averages treat the cost growth in every program equally, thus ignoring size differences (in dollar terms) between programs in the data set.

[7] A scatter plot of cost growth data points suggests a beta distribution skewed to the right. Approximately 10 percent of programs experience cost growth of more than one standard deviation above the mean. We designate these programs as having extreme cost growth.

[8] Inflation is excluded from the budgetary metrics because its estimation and ultimate effect on program costs is out of the control of the acquisition system, so its effects confound any objective assessment of the performance of that system.

[9] To make these adjustments, we compared estimated costs for the quantity common to estimates at both MS B and the current (or final) program plan. If the MS B quantity was larger than that in the current plan, then the portion of the MS B estimate representing the current quantity was calculated and compared with the current estimate for that quantity. If the MS B quantity was smaller than that in the current plan, then the portion of the current estimate representing the MS B quantity was calculated and compared with the MS B estimate.

[APUC]) and program total (program acquisition unit cost [PAUC]), indicate how accurately the program was estimated—again, in real terms—at its MS B.[10]

Table 1.1. Air Force MDAP Cost Growth Averages, Standard Deviations, and Extreme Thresholds from the 2013 President's Budget Selected Acquisition Report Data (%)

	Budgetary Cost Growth			Unit Cost Growth	
Metric	**Development**	**Procurement**	**Total**	**APUC**	**PAUC**
Average	79	92	81	63	60
Standard deviation	109	137	99	87	69
Extreme cost growth threshold	188	229	180	150	129

The highest value of cost growth in each metric from the Air Force program sample of Continuing and Complete programs is

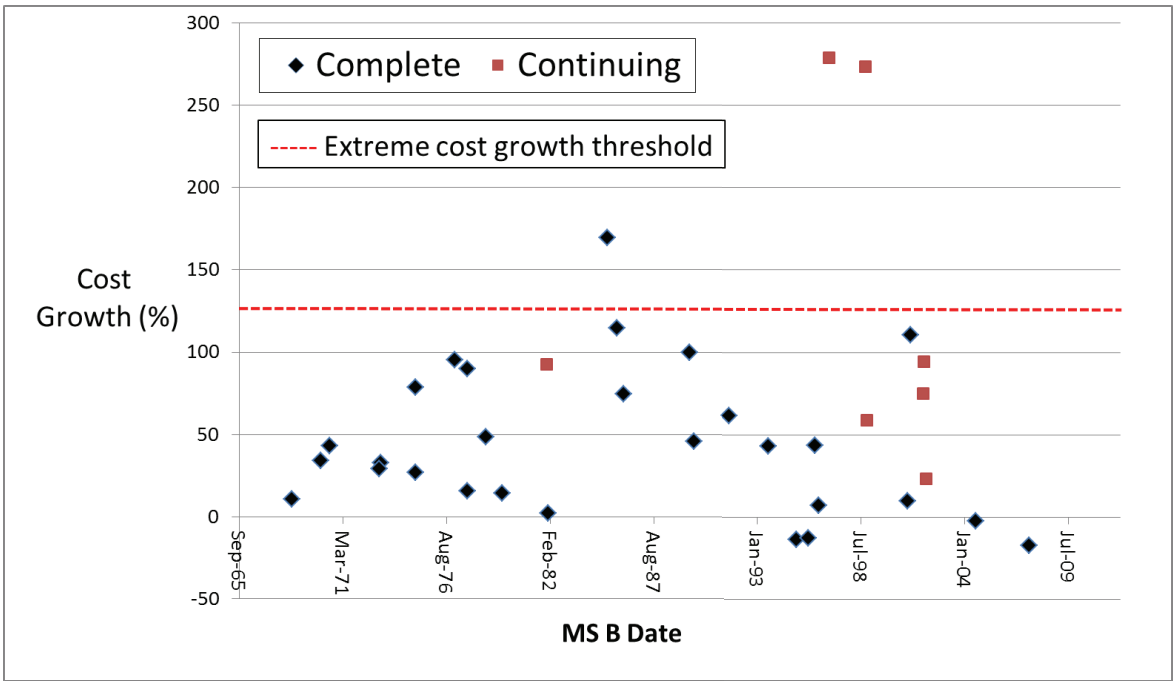
- development cost growth in Titan IV (447 percent)
- procurement unadjusted cost growth in SBIRS High (574 percent)
- total unadjusted cost growth for Titan IV (401 percent)
- APUC (quantity-adjusted) growth for SBIRS High (407 percent)
- PAUC (quantity-adjusted) growth for SBIRS High (279 percent) and for EELV (273 percent).[11]

Figure 1.4 is a scatter plot of PAUC growth in percentage terms. The programs are shown over time by MS B date along the x-axis. The y-axis value for each program is its cost growth. Three of the 36 programs show extreme cost growth: the Continuing SBIRS High and EELV as mentioned above and the Complete Titan IV launch vehicle program. The dashed line at 129 percent represents the extreme cost growth threshold value (as shown in Table 1.1) for this cost growth metric.

[10] APUC is the average cost per unit when considering the program's procurement funding only. This measure does not include the costs of development, MILCON, and acquisition-related O&M that, in aggregate, make up the entire weapon system cost. PAUC is the comprehensive measure of average unit cost. It includes all of the aforementioned acquisition cost categories.

[11] EELV SARs ceased reporting as of September 2007. This and other estimates in this report were derived from that SAR, the president's budgets (PBs) that have ensued, and a July 2012 program estimate based on 150 Air Force launch vehicles produced and flown through 2030.

Figure 1.4. Program Acquisition Unit Cost Growth in Complete and Continuing Programs



Chapter Two. Analysis of Major Defense Acquisition Programs with Substantial Air Force Funding

Each year, RAND updates the database using the latest SARs.[1] Analyses are conducted to assess the cost growth of the current programs and compare growth with that of prior programs. Analyses in the past few years have focused on cost growth from MS B in Continuing and Complete MDAPs. These analyses show cost growth experienced to date in Continuing programs versus the total cost growth experienced over the life of Complete programs.

We examine simple average and dollar-weighted average cost growth for multiple metrics. Additional analysis is conducted on the very largest of the New and Continuing programs because they have the most impact on current and future acquisition budgets. We also analyze cost growth in programs begun since 2003 to observe more-recent trends.

Fiscal Year 2012 President's Budget Findings and Changes Due to the Inclusion of the Fiscal Year 2013 President's Budget Data

2012 President's Budget Findings

First, we briefly summarize the findings from our cost growth analysis conducted when the 2012 PB SAR data (from SARs dated December 31, 2010) were the most-recent additions to the database.[2]

That analysis showed that average cost growth experienced to date in Continuing programs was higher than cost growth experienced in Complete programs. This held for all five measures of cost growth and for both raw and dollar-weighted averages. Extreme cost growth was more common in Continuing programs than in Complete programs. Complete programs tended to add units after MS B, while Continuing programs tended to subtract units after MS B.

The data also indicate that the Air Force had some success in containing cost growth in smaller programs begun since 2003. Half of these programs fall into our New category, and half fall into our Complete category (a subset of which is nearly Complete).

Finally, the F-35A, EELV, KC-46A, and Long Range Strike (LRS) Bomber represent, in aggregate, a large fraction of annual Air Force MDAP funding for the coming two decades.

[1] All MDAPs are required to submit an annual SAR dated December 31. Typically, these documents are published 60 days after the coming year's PB is submitted to Congress; by law, they are required to reflect that PB.

[2] Leonard, Wallace, and Graser, 2011.

Therefore, controlling cost growth in these four programs is of the utmost importance going forward.

2013 President's Budget

The FY 2013 PB substantially changed the Air Force's future acquisition plans. This caused important changes in the December 31, 2011, SARs, which subsequently affected some programs and their analytical categorization:

- The EELV program moved from the Complete to the Continuing category. This occurred because of the recent OSD decision to add EELV back to the active MDAP list.
- The Global Hawk program moved from the Continuing to the Complete category. This occurred because of the truncation of the program in the FY 2013 PB with no aircraft acquired after FY 2012.
- The National Polar-Orbiting Environmental Satellite System (NPOESS) and C-130 Avionics Modernization Program (AMP)[3] programs were removed from the Continuing category. This occurred because of the termination of these programs in the FY 2013 PB and their relative immaturity (little or no production completed) at the time of their termination. These two programs are no longer part of the analysis.[4]

Two additional changes were made that affected the calculation of cost growth. The dollars in the SBIRS High program MS B baseline were redistributed between the program's development and procurement efforts in light of a prior error in this distribution. This did not affect the cost growth calculation at the total program level but did cause changes to the program's development and procurement cost growth calculations. The second change was the exclusion of the budgetary cost growth for procurement value from the GBS program. Because of a more-than-14-fold increase in the program's quantity, the program experienced an 882-percent increase in unadjusted procurement cost growth. This percentage increase is so large that it distorts the computation of the average and standard deviation statistics for unadjusted procurement cost growth.[5]

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[3] The C-130 is a tactical airlift aircraft. As a result of the C-130 AMP's cancellation, there are now no electronics programs in the Continuing program data set where cost growth is measured from MS B.

[4] All terminated programs are excluded from the analysis because their data cease to represent the program content as defined at MS B and cost growth cannot be tracked to program completion. A program is considered terminated if it ultimately delivers less than 25 percent of the production quantity specified at its MS B. The program plan outlined in the NPOESS December 2011 SAR shows that no production (or development) satellites will be delivered; the December 2011 SAR for the C-130 AMP shows that just six of 218 modified aircraft will result from the production program.

[5] Note that measures of cost growth adjusted for quantity changes for this program are not now, and have not been in the past, included in the analysis because the program's units are heterogeneous. This makes the correlation between quantity and cost insufficient to confidently adjust for quantity changes.

Fiscal Year 2013 President's Budget Analysis

In early 2012, Congress received 24 SARs dated December 31, 2011, that represent the MDAPs managed by the Air Force. These SARs included both ACAT IC and ID MDAPs in which the Air Force is the primary DoD component.[6] They do not, however, include all MDAPs for which the Air Force has future funding.

Two of the 24 SARs, JASSM and Navstar GPS, contain two distinct program portions, with separate funding for each portion. Two SARs are for terminated programs—C-130 AMP and NPOESS—with no funding beyond FY 2012, so they are not part of the Air Force's future acquisition plan. Three programs with substantial Air Force funding—F-35, V-22, and AIM-X—are managed by other entities but are part of the Air Force's future acquisition plan. One program, EELV, had no current SAR as of December 2011 but has subsequently been added back to the Air Force MDAP list. The result of additions and subtractions from 24 Air Force SARs, as shown in Table 2.1, shows that there are 28 MDAPs (or portions thereof) with substantial Air Force funding in FY 2013 and future years. Programs for which an MS B baseline cost estimate is available fall into one of our previously defined analytical categories: New, Continuing, or Complete.[7]

Table 2.1. Mapping Selected Acquisition Reporting of Air Force–Managed MDAPs to MDAPs with Air Force Funding Planned for Fiscal Year 2013 and Beyond

MDAP	Number Reported
With SARs published under Air Force management	24
With multiple cost growth tracks: JASSM (baseline and extended range) and GPS UE and Block IIF acquired post-2002	+2
With no funding after FY 2012: C-130 AMP and NPOESS	–2
Led by another DoD component but with substantial Air Force funding: F-35, V-22, and AIM-9X	+3
With no current SAR: EELV	+1
Total with substantial funding for FY 2013 and subsequent years	28

NOTE: UE = user equipment. AIM-9X is an air-to-air missile.

[6] ACAT IC and ACAT ID are subcategories of ACAT I. For ACAT IC, the Milestone Decision Authority is the component head or acquisition executive. For ACAT ID, the authority is the Under Secretary of Defense for Acquisition, Technology and Logistics.

[7] Several current MDAPs of interest to the Air Force did not begin SAR reporting until well after their MS Bs or did not have an MS B. As a result, no MS B cost baseline estimate is available for these programs, and they cannot be included in our analysis. These programs are HC/MC-130J, Reaper, C-130J, JASSM-ER, FAB-T, AIM-9X Block 2, and several with less than $1 billion in future funding (FY 2013 and subsequent years).

Table 2.2 represents the overall status of future Air Force MDAP funding. The table shows past and future funding for the 28 programs. All funding shown is in FY 2012 dollars, thus facilitating the comparison of the values of each program. The left data column shows each program's funding in FY 2012 and prior years. The right data column shows each program's FY 2013 and future funding. The programs are ordered lowest to highest future funding.

Table 2.2. Past and Future Funding in MDAPs with Planned Funding in Fiscal Year 2013 and Later Years (millions of FY 2012 dollars)

Program	FY 2012 and Prior Years	FY 2013 and Future Years
GPS UE	9,477.3	28.9
MP-RTIP	1,390.1	62.0
B-2 EHF I-1	486.3	100.0
National Airspace System	1,520.8	115.0
GBS	1,062.2	129.4
GPS Sat 2003	3,800.7	175.9
WGS	3,682.6	364.4
C-27J joint cargo aircraft	1,874.9	411.8
JDAM	6,391.0	489.7
JPATS T-6A	5,181.2	637.2
V-22 Osprey	4,962.3	760.9
Global Hawk	8,944.7	899.5
JASSM	2,578.1	1,152.7
GPS III	2,807.9	1,359.8
Air Force AIM-9X Blk 2	266.3	2,455.7
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	2,033.7	2,472.6
C-5 RERP	4,874.7	2,579.4
SDB II	850.0	2,948.1
JASSM-ER	340.5	2,961.9
AEHF	11,142.9	2,989.8
Air Force AMRAAM (AIM-120A)	13,643.0	4,342.5
SBIRS High	13,662.2	4,925.4
C-130J	11,023.4	5,151.7
Reaper	4,632.0	7,636.0
HC/MC-130J	4,274.1	8,622.1
KC-46	1,857.1	42,175.5
EELV	11,872.2	42,276.6
F-35A	38,031.0	164,654.0

The F-35A, the Air Force portion of the F-35 (Joint Strike Fighter) program, has both the largest past funding of any single program at $38.0 billion, and the largest future funding at $164.7 billion. The F-35A represents 54 percent of all currently planned future funding for MDAPs that have achieved MS B.[8] The EELV and KC-46 programs have roughly equal future funding at $42.3 billion and $42.2 billion, respectively. Each of these two programs represents 14 percent of all currently planned future funding. Combined future acquisition funding in these three programs make up 82 percent of the total for all 28 programs.

Comparing Cost Growth in Complete and Continuing Programs

Figures 2.1 through 2.3 show total program costs (development, procurement, MILCON, and acquisition-related O&M) without adjusting for quantity changes from those specified at MS B. These figures are useful in understanding the effect of cost growth on Air Force acquisition budgets over time. Of the 36 Air Force programs suitable for analysis, 29 are Complete (or nearly Complete) and seven are Continuing. Cost growth in the Complete programs provides an indication of the difficulty of accommodating cost growth over the past 40 years, while growth to date in the Continuing programs provides an indication of the difficulty in accommodating cost growth in more-recent years and into the future (through the Future Years Defense Program [FYDP] and well past it).

Figure 2.1 compares the values of the programs in these two categories at each MDAP's MS B, shown in billions of FY 2012 dollars. On the left is the cumulative estimated value of MDAPs at their MS Bs that are now in our Complete category by weapon system type; on the right is the cumulative estimated value of MDAPs at their MS Bs that are now in our Continuing category. On both sides, the programs are grouped by weapon system type.

Several observations from the figure are worthy of note. The total estimated value at MS B of the 29 Complete programs is $318.8 billion, while that for the seven Continuing programs at their MS Bs is $172.1 billion. The Complete programs are dominated by aircraft, both fighters (F-15, F-16, F-22) and nonfighters (A-10, B-1B, C-17, E-3A, E-4, RQ-4A, T-6A/B, E-8), while the Continuing programs are dominated by the F-35A (the only program in the "various fighters" type). The estimated value of the three Continuing space programs is $87.5 billion, while that of the five Complete space programs is just $34.8 billion. There are no electronics programs in the Continuing category.

[8] Note that the LRS Bomber program has not yet achieved MS B and is therefore not considered in this calculation.

Figure 2.1. Comparison of Air Force Complete and Continuing Program Estimated Values Using Each Program's Milestone B Cost Estimate

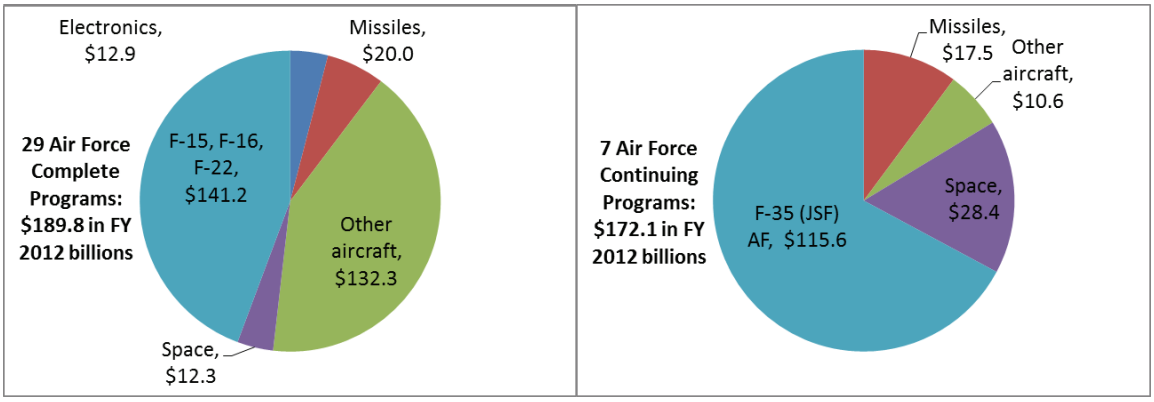


Figure 2.2 compares the values of the Complete and Continuing programs as of each MDAP's final SAR or as estimated in the FY 2013 PB. The estimated value of the Continuing programs, $324.8 billion, has grown (on a percentage basis) more than that of the Complete programs, $473.6 billion. Note that no additional cost growth will occur in the Complete programs, but it is likely that costs will grow further in the Continuing. In addition, on average, the Complete programs added units to their production quantities from the time of their MS Bs to their completion, while the Continuing programs, on average, subtracted units from the time of their MS Bs to their most-recent estimates.

As with the previous figure, the majority of dollars in the Complete programs are in aircraft, both fighters and nonfighters, and the majority of dollars in the Continuing programs are in the F-35A program. The estimated value of the F-35A program has now grown to roughly equal that of the F-22, F-15, and F-16 programs combined at those programs' final SARs.[9]

In Figure 2.2, the estimated value of the space programs in the Continuing category is $87.5 billion, or 27 percent of the total. That in the Complete data set is $34.8 billion, or 7 percent of the total. In both categories, these programs have roughly tripled in cost.

[9] The final SARs for the F-22, F-15, and F-16 were submitted in December 2010, December 1990, and December 1994, respectively. The procurement quantities in these final SARs were 179, 1,074, and 2,201, respectively. These quantities represent a 72-percent decrease in the F-22 program, a 47-percent increase in the F-15 program, and a 239-percent increase in the F-16 program from their MS B planned quantities. The planned production quantity for the Air Force version of the F-35 program has not changed from its MS B plan.

Figure 2.2. Comparison of Air Force Complete and Continuing Program Estimated Values as of Each Program's Final Selected Acquisition Report or Fiscal Year 2013 President's Budget Cost Estimate

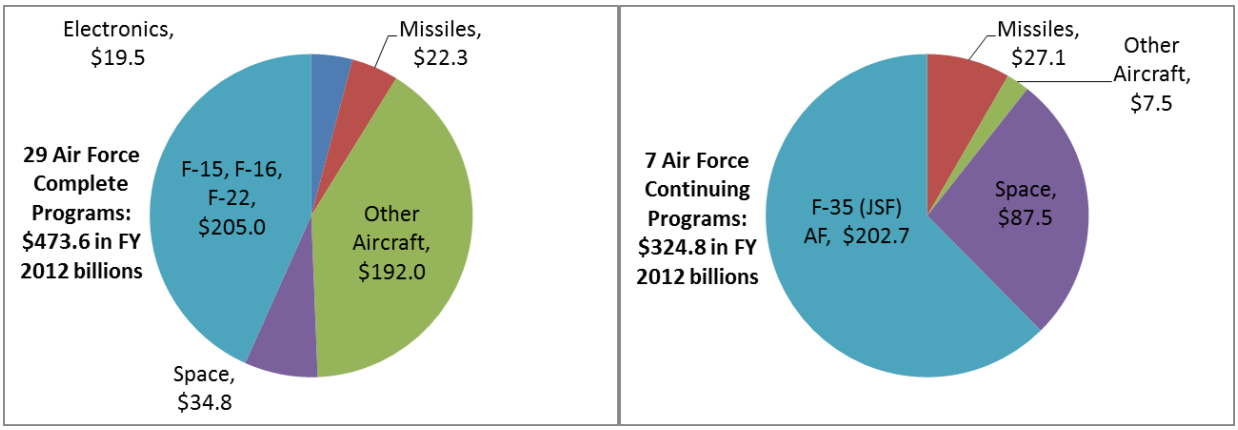
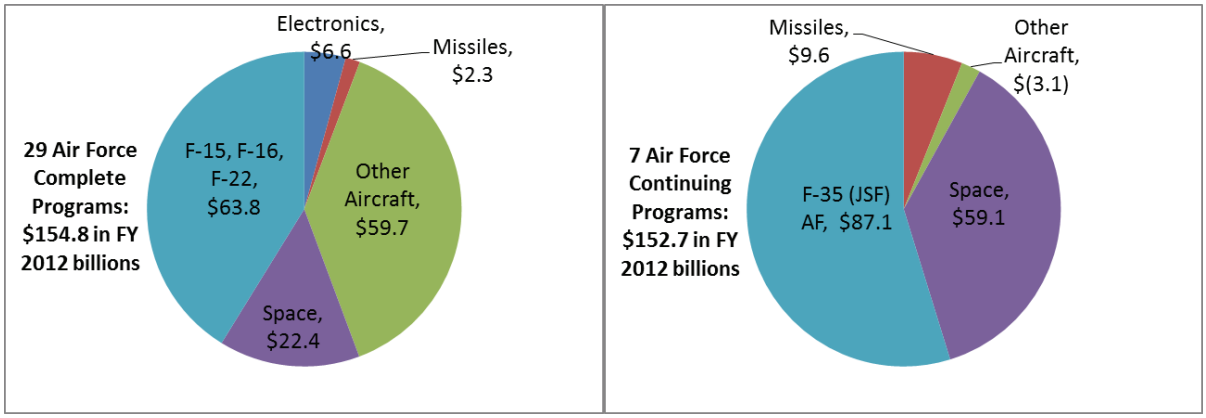


Figure 2.3 compares cost growth in the Complete programs with that in the Continuing programs to date. As in the prior two figures, aircraft dominate cost growth in Complete programs. In the Complete programs, space program cost growth makes up a much higher percentage of cost growth (14.5 percent = $22.4 billion ÷ $154.8 billion) than its fraction of program value at MS B (3.9 percent = $12.3 billion/$318.8 billion). In the Continuing programs, the F-35A's $87.1 billion in cost growth dominates that in all other programs combined. This single program accounts for more than half of the cost growth in the seven-program Continuing programs. As in the Complete programs, space programs in the Continuing category make up a much larger percentage of cost growth than their percentage of the total at MS B would suggest. These programs account for 38.7 percent of all cost growth ($59.1 billion/$152.7 billion) but represent only 16.5 percent ($28.4 billion/$172.1 billion) of the value of all Continuing programs at their MS Bs.

Figure 2.3. Comparison of Dollar-Value Cost Growth in Air Force Complete and Continuing Program Estimates



In sum, Figures 2.1 through 2.3 illustrate that cost growth in the F-35A program estimate to date far exceeds that of the three prior fighter programs and dominates the Continuing programs. The larger fraction of space programs in the Continuing category, coupled with generally higher cost growth in space programs (both Complete and Continuing), explains much of the higher cost growth to date in the Continuing category. The results are virtually identical when analyzing quantity-adjusted space program estimates in the Continuing programs.[10]

Comparing Cost Growth Using Five Metrics

As shown in Table 1.1 in Chapter One, we calculate five different cost growth metrics to gain an understanding of effects on budgets and of how well programs are estimated at MS B. Table 2.3 shows simple average, standard deviation, and median values for the sets of program categorized as Complete and Continuing. The simple average method weights all programs equally, regardless of their dollar values. The three data columns on the left show the metrics for budgetary impacts of cost growth for development, procurement, and program total. The rightmost data columns are adjusted for quantity changes and therefore indicate cost growth by unit for procurement (APUC) and program total (PAUC). These two metrics indicate how well programs were estimated at MS B: The higher the cost growth, the less accurate the MS B estimates.

Table 2.3. Comparing Cost Growth in Complete and Continuing MDAPs (%)

	Budgetary Cost Growth			Unit Cost Growth	
Measure	**Development**	**Procurement**	**Total**	**APUC**	**PAUC**
Average					
Complete	82	68	73	35	45
Continuing	67	188	115	174	128
Standard deviation					
Complete	116	105	96	34	45
Continuing	79	208	114	138	104
Median					
Complete	38	41	44	31	39
Continuing	44	93	75	95	93

NOTE: The underlying data are identical to those used to calculate the values shown in Table 1.1 in Chapter One.

[10] Cost growth in the AEHF, EELV, and SBIRS High programs when not adjusted for quantity change is 119 percent, 210 percent, and 315 percent, respectfully, for an average of 215 percent. When adjusted for quantity change, the cost growth is 95 percent, 273 percent, and 279 percent, respectively, for the three MDAPs, for an average of 216 percent.

Continuing programs already have higher average cost growth than Complete programs in every metric except development. Prior to the recent truncation of the Global Hawk program (which was subsequently moved from the Continuing to the Complete category) and the termination of the C-130 AMP and NPOESS programs (which are no longer included in the analysis), cost growth for Continuing programs in development was higher as well. Most striking in the table are the differences between Complete and Continuing simple average cost growth for the unit measures. Differences in the medians for the Complete and Continuing programs are just as stark.

Statistical analysis conducted on cost growth measurements in the Continuing and Complete programs found the following:[11]

- Average cost growth for development is 15 percent lower in the Continuing programs than in the Complete programs (67 percent versus 82 percent). This difference is not statistically significant.
- Average cost growth for procurement unadjusted for quantity changes is 120 percent higher in the Continuing programs than in the Complete ones (188 percent versus 68 percent). This difference is statistically significant only if one relaxes the confidence level from the customary 95 percent to 90 percent.
- Average cost growth for program total unadjusted for quantity changes is 42 percent higher in the Continuing programs than in the Complete ones (115 percent versus 73 percent). This difference is not statistically significant.
- Average cost growth for APUC (procurement adjusted for quantity changes) is 139 percent higher in the Continuing programs than in the Complete ones (174 percent versus 35 percent). This difference is statistically significant.
- Average cost growth for PAUC (program total adjusted for quantity changes) is 83 percent higher in the Continuing programs than in the Complete ones (128 percent versus 45 percent). This difference is statistically significant.

The results for quantity-adjusted metrics indicate that estimates at MS B were much more accurate for the Complete programs than the Continuing ones.

Three characteristics affect the cost growth differential between the Continuing and Complete programs. The first is average program length. As mentioned earlier, the Continuing programs are, on average, 1.6 years longer past their MS B than are the Complete ones (14.6 years versus 13.0 years). Statistical testing using all programs showed that longer programs do indeed have higher cost growth in all five cost growth metrics. The additional cost growth associated with the longer average duration in Continuing programs is shown in Table 2.4 below.

[11] In the context of statistical testing, the Complete and Continuing data sets are small, and their measurements of cost growth are not normally distributed. As a result, the two-sample standard Wilcoxon nonparametric test was used to determine statistical significance.

Table 2.4. Average Additional Cost Growth with 12 Percent Longer Average Duration in Continuing Programs Versus Complete Programs (%)

	Budgetary Cost Growth			Unit Cost Growth	
Measure	**Development**	**Procurement**	**Total**	**APUC**	**PAUC**
Average additional cost growth	6.3	7.4	7.2	3.5	4.8

The second characteristic affecting cost growth in the Continuing programs is the concentration of space programs among them. Three of the seven Continuing programs are space programs; only five of 31 Complete are space. As shown in Table 2.5, cost growth is considerably higher for space programs in all five metrics. Statistical analysis was conducted on cost growth measurements in space and nonspace (all other) programs.[12]

- Average cost growth for development is 126 percent higher in the space programs than in nonspace programs (179 percent versus 53 percent). This difference is statistically significant.
- Average cost growth for procurement unadjusted for quantity changes is 192 percent higher in space programs than in the nonspace programs (240 percent versus 48 percent). This difference is statistically significant.
- Average cost growth for program total unadjusted for quantity changes is 137 percent higher in space programs than in nonspace programs (187 percent versus 50 percent). This difference is statistically significant.
- Average cost growth for APUC (procurement adjusted for quantity changes) is 99 percent higher in space programs than in nonspace programs (139 percent versus 40 percent). With a 17-percent probability that this difference is coincidental, this result is considered not statistically significant.
- Average cost growth for PAUC (program total adjusted for quantity changes) is 88 percent higher in space programs than in nonspace programs (129 percent versus 41 percent). This difference is statistically significant.

Table 2.5. Average Cost Growth in Space and Nonspace Programs (%)

	Budgetary Cost Growth			Unit Cost Growth	
Program Category	**Development**	**Procurement**	**Total**	**APUC**	**PAUC**
Space	179	240	187	139	129
Nonspace	53	48	50	40	41

[12] In the context of statistical testing, the space and nonspace data sets are small, and their measurements of cost growth are not normally distributed. As a result, the two-sample standard Wilcoxon nonparametric test was again used to determine statistical significance.

Given these results, it appears that the high concentration of space programs among the Continuing programs is a substantial contributor to their higher cost growth in comparison with the Complete programs.

The third characteristic that may affect cost growth in the Continuing programs is the lack of electronics programs among them. None of the seven Continuing programs is an electronics program; 11 of the 31 Complete programs are electronics. As shown in Table 2.6, cost growth is considerably lower for electronics programs in all five metrics. Statistical analysis was conducted on cost growth measurements in electronics and nonelectronics (all other) programs.[13]

- Average cost growth for development is 91 percent lower in electronics programs than in nonelectronics (15 percent versus 106 percent). This difference is statistically significant.
- Average cost growth for procurement unadjusted for quantity changes is 71 percent lower in electronics programs than in nonelectronics (37 percent versus 108 percent). This difference is not statistically significant.
- Average cost growth for program total unadjusted for quantity changes is 57 percent lower in electronics programs than in nonelectronics (38 percent versus 95 percent). With an 18-percent probability that this result is coincidental, this difference is considered not statistically significant.
- Average cost growth for APUC (procurement adjusted for quantity changes) is 47 percent lower in electronics programs than in nonelectronics (26 percent versus 74 percent). This result is statistically significant only if one relaxes the certainty threshold to 90 percent confidence from the customary 95 percent confidence.
- Average cost growth for PAUC (program total adjusted for quantity changes) is 59 percent lower in electronics programs than in nonelectronics (16 percent versus 75 percent). This difference is statistically significant.

Table 2.6. Average Cost Growth in Electronics and Nonelectronics Programs (%)

	Budgetary Cost Growth			Unit Cost Growth	
Program Category	**Development**	**Procurement**	**Total**	**APUC**	**PAUC**
Electronics	15	37	38	26	16
Nonelectronics	106	108	95	74	75

Given these results, it appears that the absence of electronics programs (that tend to have lower cost growth) among the Continuing programs is a substantial contributor to that group's higher average cost growth in comparison with that of the Complete programs.

Dollar-weighted averages for the Complete and Continuing programs and five cost growth metrics are shown in Table 2.7. Weighted average cost growth provides an understanding of the

[13] In the context of statistical testing, the electronics and nonelectronics data sets are small, and their measurements of cost growth are not normally distributed. As a result, the two-sample standard Wilcoxon nonparametric test was again used to determine statistical significance.

additional dollars required at the total Air Force acquisition budget level over time to cover the realized cost growth in the MDAP portfolio. Because cost growth in each program is weighted, very large programs (such as the F-35A in the Continuing category) dominate the calculation, while very small programs (such as the B-2 RMP in the Complete category) have little effect.

Although the differences between the two categories are less striking in the weighted averages than the simple averages, one draws the same conclusion: With the exception of development, the Continuing programs have already experienced much higher cost growth than the Complete programs experienced over their entire acquisition time periods.

Table 2.7. Weighted Average Percentage Cost Growth in Complete and Continuing MDAP Estimates (%)

	Budgetary Cost Growth			Unit Cost Growth	
Category	Development	Procurement	Total	APUC	PAUC
Complete	68	42	49	40	47
Continuing	63	95	89	109	99

Extreme Cost Growth in Complete and Continuing Programs

Given the findings shown in the preceding figures and tables, it is not surprising that extreme cost growth, as defined in Chapter One in Table 1.1, is more common in Continuing than in Complete programs. Figure 2.4 shows the frequency of extreme cost growth in each of the five metrics. In the Complete programs, extreme cost growth in development occurs in four of 31 programs,[14] or 13 percent. In procurement unadjusted for quantity changes and program total unadjusted for quantity changes, the frequency is four of 29 programs, or 14 percent. In the unit metrics, extreme cost growth occurs in zero and one of the 29 programs, respectively, for procurement and program total.

Except in development, extreme cost growth frequency is far higher in Continuing programs. One of the seven, or 14 percent of Continuing programs, has extreme cost growth in development. In the procurement metrics, both unadjusted and unit, three of the seven, or 43 percent, have extreme cost growth. In the program total metrics, both unadjusted and unit, two of the seven, or 29 percent, have extreme cost growth. All instances of extreme cost growth in the Continuing programs are in space programs.

[14] Two of the Complete programs contained development funding only. They are therefore included in the analysis of only this single cost growth metric.

Figure 2.4. Frequency of Extreme Cost Growth in Complete and Continuing Programs

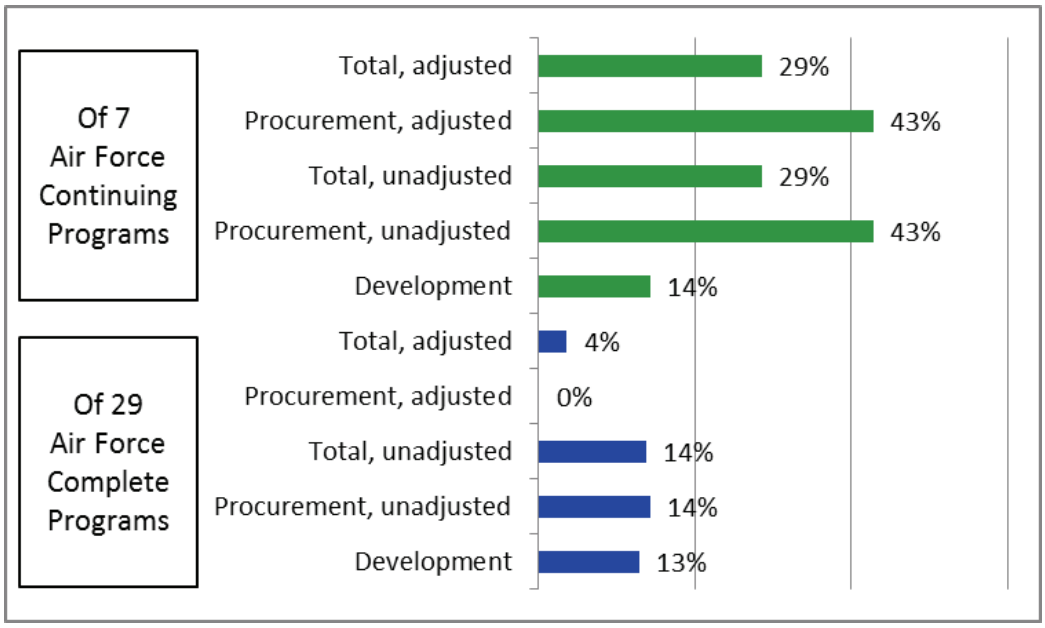


Table 2.8 shows the details of cost growth in the seven Continuing programs. The top three, all space programs, have experienced extreme cost growth in at least one metric; none of the bottom four has as of the December 2011 SARs. The top three programs are listed in order by the number of cost growth metrics that are extreme:

- SBIRS High is the only program with extreme cost growth in all five metrics. Its cost has increased $14.8 billion, with a relatively small fraction of that due to the total number of satellites planned for acquisition increasing from five at MS B to six as of the program's December 2011 SAR.
- EELV has extreme cost growth in four of the five metrics and has by far the largest estimated growth in dollars of the space programs at $36.7 billion through program completion of 150 Air Force launch vehicles in 2030. The program had planned 181 units at its MS B, so its cost increase is somewhat lower than it would have been had the quantity not been cut.
- AEHF has extreme cost growth in the two procurement-related metrics. Its cost has increased $7.6 billion, with a relatively small fraction of that due to the total number of satellites planned for acquisition increasing from five at MS B to six as of the program's December 2011 SAR.

The bottom four programs are listed in order of their cost growth as measured in FY 2012 dollars:

- The estimated dollar value of cost growth for the 1,768 F-35A Air Force aircraft (five development and 1,763 procurement) is $87.1 billion. The percentage cost growth estimates for the F-35A are generally above average but are much lower than those in the space programs and are nowhere near the extreme thresholds.

- The AMRAAM program has been ongoing for more than 30 years, making it by far the longest running of the Continuing programs. Note that costs have almost doubled in the unit measures. Despite a substantial quantity reduction from 24,504 missiles planned at MS B to 16,350 as of the program's December 2011 SAR, the program's cost has increased $8.2 billion.
- For a time, cost growth in the JASSM program was higher than shown below because the improved variant, the JASSM-ER, was included in the baseline program. With the removal of JASSM-ER units into a separate MDAP, the basic JASSM program again represents the general configuration and quantity planned for at its MS B. The program's costs have increased $1.4 billion, with almost all of the increase in procurement costs.
- The C-5 RERP has had virtually no development cost growth. In procurement and total in the budgetary metrics, costs have decreased because of a quantity cut from 112 to 52 aircraft modified. Cost growth in both unit metrics is the lowest of the seven Continuing programs. The program's costs have decreased $3.1 billion, entirely because of the quantity cut.

Table 2.8. Cost Growth in Continuing Program Estimates as of the Fiscal Year 2013 President's Budget

		Budgetary Cost Growth (%)			Realized Cost Growth (millions of FY 2012 dollars)	Unit Cost Growth (%)	
Program	MS B Date	Development	Procurement	Total		Procurement	Total
SBIRS High	November 1996	235	574	315	14,800	407	279
EELV[a]	October 1998	29	229	210	36,700	299	273
AEHF	November 2001	58	325	119	7,600	217	95
F-35A	October 2001	44	82	75	87,100	82	75
AMRAAM	December 1981	81	50	55	8,200	95	93
JASSM	November 1998	19	93	59	1,400	93	59
C-5 RERP	December 2001	1	–36	–30	–3,100	28	23

[a] EELV cost growth estimated using the program's September 2007 SAR, subsequent FYDPs, and multiple publicly available publications.

In a forthcoming report, we discuss the underlying factors that have led to extreme cost growth in the three space programs shown in Table 2.8, along with three programs terminated or truncated in the FY 2013 PB (discussed early in this chapter).[15] In short, there are no "good" explanations (e.g., huge quantity increases, circumstances beyond the program's control precipitating massive additional requirements) for the extreme cost growth in these six programs. Instead, extreme cost growth occurred because of highly optimistic assumptions, immature design solutions, unproven technologies, and unrealistic MS B baseline estimates.

[15] Lorell, Leonard, and Doll, draft in process.

Cost Growth in Programs Begun Since 2003

Cost growth appears to be much lower in the six programs begun by the Air Force from 2003 through 2011. As shown in Table 2.9, five of these six are of low value by MDAP standards. The exception, the KC-46A program, is the newest of the programs. Three of the six programs are Complete or nearly Complete. These three are much shorter in length than the average for the Continuing and Complete programs, and all three are categorized as electronics. Both of these characteristics are associated with lower cost growth.

The remaining three are less than five years past MS B and are thus in our New category. According to the FY 2013 FYDP, GPS IIIA will be nearly complete by the end of FY 2013. This space program is the only one of the six begun since 2003 that has experienced positive cost growth (thus far). SDB II will be nearly complete in FY 2021, 11 years past its MS B. The KC-46A is the only program of the six that is expected to continue longer than the averages of the Continuing and Complete programs.

Table 2.9. Estimated Cost Growth Values in Air Force MDAPs Begun Between 2003 and 2011

				Total Program, Unadjusted (millions of FY 2012 dollars)		
Program	Status	MS B Date	Years Since MS B	MS B Estimate	December 2011 SAR Estimate	Realized Growth (millions of FY 2012 dollars)
MP-RTIP	Complete	December 2003	8.1	1.82	1.45	–0.36
B-2 RMP	Complete	August 2004	7.4	1.36	1.29	–0.07
B-2 EHF I-1	Nearly complete	May 2007	4.6	0.72	0.64	–0.08
GPS IIIA	New	May 2008	3.6	3.98	4.16	0.18
SDB II	New	August 2010	1.4	4.76	3.80	–0.96
KC-46A	New	February 2011	0.8	44.35	44.04	–0.29

The "realized growth" column at the far right of the table shows that, in all but one of the programs, cost estimates have decreased since MS B. The lone increase, in the GPS IIIA program, is only about 4 percent. These data suggest that the Air Force has controlled cost growth in the five smaller, shorter MDAPs. The challenge now is to control costs in larger MDAPs, such as the recently begun KC-46A and the soon-to-begin LRS Bomber.

Chapter Three. Findings for Major Defense Acquisition Programs with Substantial Air Force Funding

The averages for all acquisition cost growth metrics except development are substantially higher in Continuing programs than Complete programs, indicating that Continuing programs have already experienced a higher rate of cost growth than Completed programs. This finding is statistically significant after adjusting for production quantity changes. Explanations that contribute to this finding are the longer average durations of the Continuing programs, the high frequency of space programs among the Continuing programs, and the absence of electronics programs among the Continuing programs.

The lower average cost growth in development for Continuing programs was a change from the prior year's analysis, in which Continuing programs had higher cost growth in all five metrics.[1] This change occurred because of the FY 2013 PB, in which three Air Force MDAPs were removed from future acquisition funding plans: the NPOESS and C-130 tactical airlift aircraft AMP were cancelled, thus removing them from the analysis, and the Global Hawk remotely piloted surveillance aircraft program was truncated, thus reclassifying it as a Complete program. Development cost growth in these three programs was in excess of 150 percent.

Three Continuing space programs drive the higher cost growth averages. However, in dollar terms, cost growth in the Air Force portion of the F-35 program (F-35A) dominates the data set. On a percentage basis, cost growth in the F-35A program is above average but not nearly high enough to be extreme (i.e., cost growth larger than one standard deviation above the mean). However, at $87.1 billion (FY 2012 dollars) it is much larger in dollar terms than the cost growth of all other Continuing programs combined.

The three space programs with extreme cost growth (SBIRS High, AEHF, and EELV) plus the F-35A make up more than 95 percent of the cost growth in the Continuing programs. With the 2013 PB's cancellation of future acquisition in three additional programs with extreme cost growth (NPOESS, C-130 AMP, and Global Hawk), these programs are no longer part of future MDAP budgets.

There appears to be minimal cost growth thus far in MDAPs begun between 2003 and 2011 that have substantial Air Force funding. Six MDAPs with both high development content and substantial Air Force funding were begun between 2003 and 2011. Three (MP-RTIP, B-2 strategic bomber aircraft RMP, and B-2 EHF I-1 satellite communication upgrade) were relatively low value by MDAP standards and short in duration. They are categorized as Complete programs and had essentially zero cost growth. The other three (GPS IIIA satellite

[1] Leonard, Wallace, and Graser, 2011.

navigation system, SDB II, and KC-46A aerial refueling and strategic transport aircraft) are considered to be New programs at the time of this analysis because not enough time has passed since their MS Bs to make an assessment of their cost growth in relation to other programs that are further along in the acquisition process. Through the FY 2013 PB SARs, none of these three programs has had cost growth of more than about 4 percent.

Four programs in aggregate are expected to consume a large fraction of annual Air Force MDAP acquisition funding in the coming 20 years: F-35A, EELV, KC-46A, and the LRS Bomber. The first two are well along in the acquisition process but have decades of production to come. Opportunity remains to stem the cost growth in these programs. The second two are earlier in the acquisition process and thus provide greater opportunities to ensure affordability and minimal future cost growth. Controlling the cost of these four high-value programs is essential to ensuring both their affordability and that of the entire Air Force weapon system acquisition portfolio for decades to come.

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